D/7

PHYS 122 SOLN **EXAM III** **December 1, 2011**
Prof. S.M. Bhagat

Name:

(Sign in ink, print in pencil)

Notes

1. There are six (6) problems in this exam. Please make sure that your copy has all of them.
2. Please show your work, indicating clearly what formula you used and what the symbols mean. Just writing the answer will not get you full credit. In stating vectors, give both magnitude and direction.
3. Write your answers on the sheets provided.
4. Do not forget to write the units.
5. Do not hesitate to ask for clarification at any time during the exam. You may buy a formula at the cost of one point.

Take Care! God Bless You!

$$k_e = 9\times 10^9 \frac{N\cdot m^2}{C^2}$$

$$\varepsilon_0 = 9\times 10^{-12}\, F/m$$

Mass of proton	$m_p = 1.6\times 10^{-27}\,kg$
Mass of electron	$m_e = 9\times 10^{-31}\,kg$
Elementary Charge	$e = 1.6\times 10^{-19}\,C$

$$\mu_0 = 4\pi\times 10^{-7}\, H/m$$

NO CACULATORS!

Prob1a Write down Ampere's law, defining the sum on the left side of the equation precisely. (6)

A current generates a $\vec{B}$ field which circulates around it. Hence circulation of $\vec{B}$ around a closed loop is determined by the currents flowing through the surface on which the loop is drawn:

$$\sum_c \vec{B}_i \cdot \vec{\Delta l} = \mu_0 \sum I$$

↙ circulation.

Prob1b A cylindrical shell of radius R which is much larger than its thickness t = 1mm carries a current density $\underset{\rightarrow}{J} = 5 amp/m^2 \hat{y}$. Show that the $\underset{\rightarrow}{B}$ field jumps by ($2\pi \times 10^{-9}$) T as its surface is crossed. (10)

Ampere's law

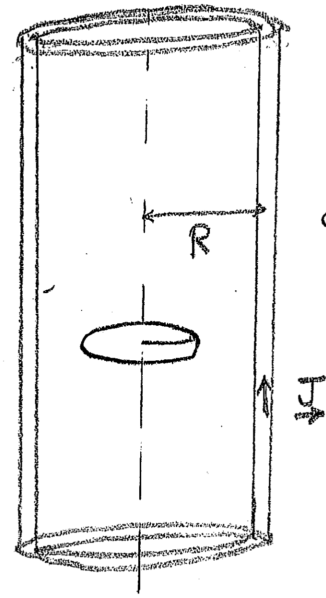
$\sum_{c} \underline{B} \cdot \Delta \underline{\ell} = \mu_0 \Sigma I$.

Need loop?

Symmetry is cylindrical about axis.

B can be a fn. of r only.

Loop: Circle of radius r centered on axis:



Current $I = 2\pi R t J$.

$r < R$ $B(r)\, 2\pi r = 0$ ← No current

$r > R$ $B(r)\, 2\pi r = \mu_0 I$

$$B(r) = \frac{\mu_0 I}{2\pi r}$$

On surface $r = R$.

$$B(R) = \frac{\mu_0 I}{2\pi R} = \mu_0 J t$$

$4\pi \times 10^{-7} \times 5 \times 10^{-3}$ T

Prob 2a What is sound? What is light? Give precise definitions. (3,3)

Sound: Any mechanical wave whose freq. is between 20Hz & 20kHz

Light: Transverse EM wave, speed in vac 3×10^8 m/s wavelengths in vac

$400nm < \lambda < 700nm$.

Prob 2b List 5 notable differences between light and sound. (10)

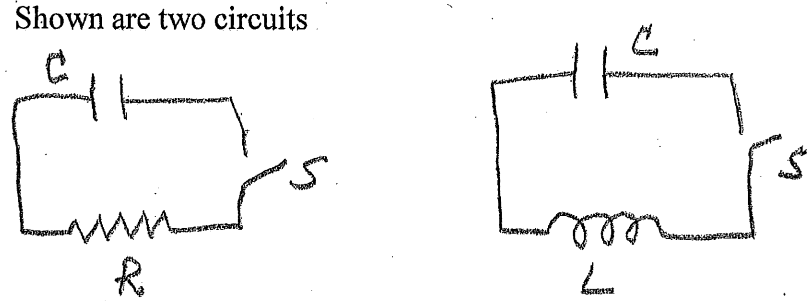
Sound	Light
NO SOUND IN VAC	TRAVELS IN Vac.
LONGITUDINAL IN GAS	TRANSVERSE
MECHANICAL (Displ, Press).	ELECTROMAGNETIC (E,B)
speed in air 340m/s	speed in air 3×10^8 m/s.
f ~ 20Hz–20kHz	~ 10^{14} Hz

Prob 3a What is the difference between a resistor and an inductor? (3,3)

A resistor is like friction, it dissipates Electrical energy $P_W = I^2R = \frac{V^2}{R}$.

An Inductor stores energy in a B-field. $U_B = \frac{1}{2} L I^2$

Prob 3b Shown are two circuits



In both cases, the capacitor is charged to (+Q, -Q) and the switch is closed. How will the charge on C vary with time? Why? (10)

→ Resistor dissipates energy so C discharges

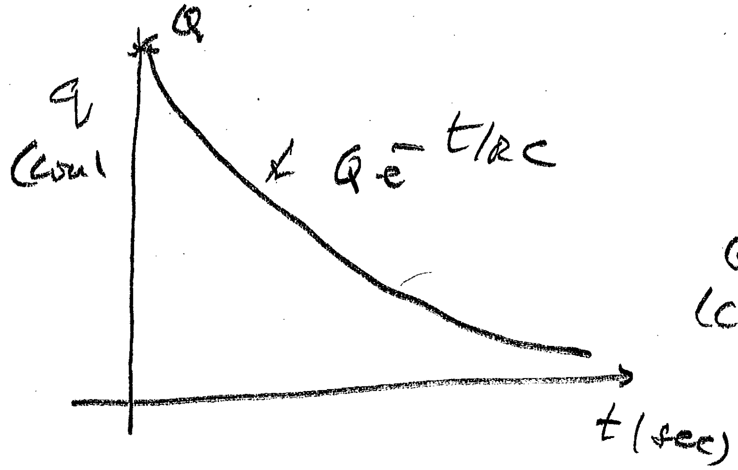
Inductors energy accepts from C & cancels it back

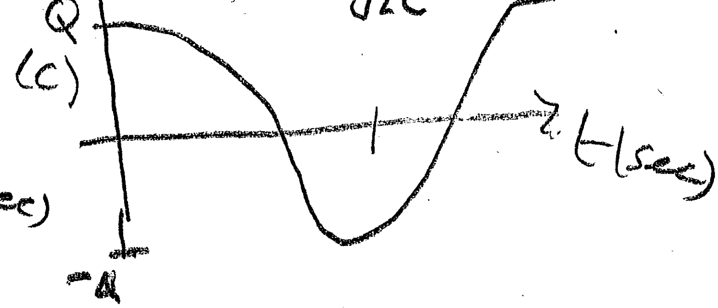
Conservation Eqn

$$\frac{Q^2}{2C} = \frac{q^2}{2C} + \frac{1}{2} L i^2$$

q oscillates

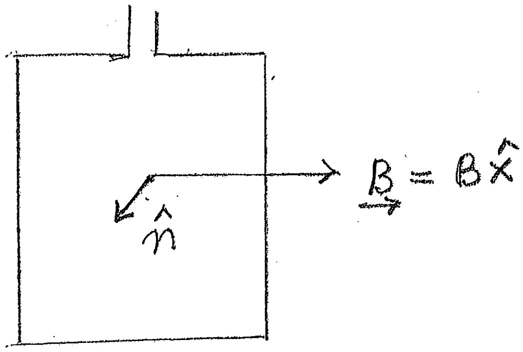
$$\omega = \frac{1}{\sqrt{LC}}$$





5|7

<u>Prob 4</u> Shown is a coil of area A suspended in a $\underset{\rightarrow}{B}$ – field and free to rotate about y-axis. (i) How would you use it as a generator? (ii) What is the maximum emf it will generate? (iii) Show that the maximum emf occurs when the flux of $\underset{\rightarrow}{B}$ through the coil is zero. (5,10,5)



$$\mathcal{E} = -\frac{\Delta \Phi_B}{\Delta t}$$

$$\Phi_B = BA \cos(\hat{n}, \underset{\rightarrow}{B})$$

Max $\mathcal{E}$ $\quad 2vBl = BA\omega$

6/7

Prob 5a Why did Maxwell introduce a displacement current? (6)

The field Eqns. before Maxwell

Ampere → $\sum_C \vec{B} \cdot \Delta \vec{l} = \mu_0 \sum I$

Faraday-Lenz $\sum_C \vec{E}_{NC} \cdot \Delta \vec{l} = - \frac{\Delta \phi_B}{\Delta t}$

Maxwell's concern was that there must be symmetry between $\underline{B}$ & $\underline{E}$ if $\frac{\Delta \phi_B}{\Delta t}$ creates $\vec{E}_{NC}$, $\frac{\Delta \phi_E}{\Delta t}$ must create $\underline{B}$. Since every current creates $\vec{B}$ he postulated

Prob 5b What is the difference between a displacement current and a conduction current? (5,5)

$i_D = \varepsilon_0 \frac{\Delta \phi_E}{\Delta t}$

displacement current arises when flux of $\underline{E}$ varies with time.

$i_D = \varepsilon_0 \frac{\Delta \phi_E}{\Delta t}$ ← exists in vacuum

Conduction current represents flow of charge in a conductor

$i_C = \frac{\Delta q}{\Delta t}$

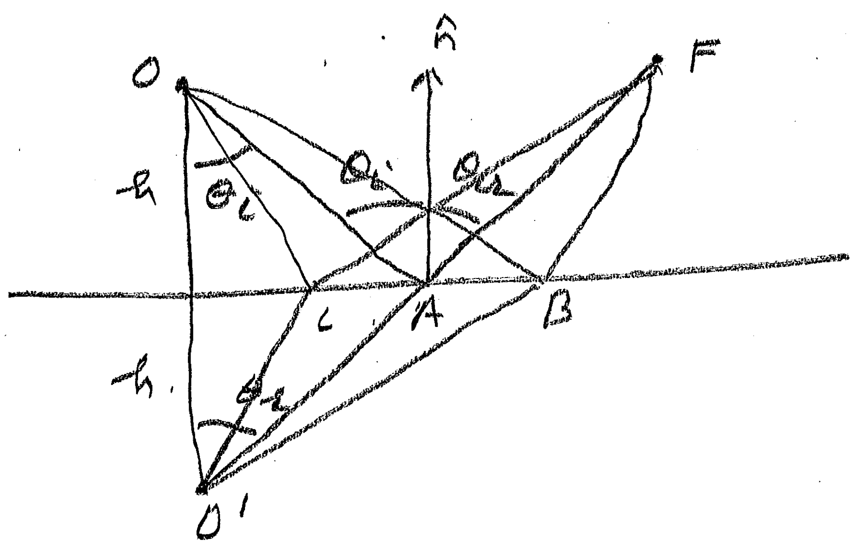
Prob 6a State Fermat's principle for propagation of light. (6)

Fermat's principle states that light will follow a path which takes the least time

Prob 6b Use Fermat's principle to show that the angle of reflection is equal to the angle of incidence. (10)

Let light Start at O
drop perp.
go to O'
Draw O'F

Since $\theta_r = \theta_i'$
light follows shortest path is OAF



OCF & OBF both larger than OAF